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# Denitrification using a monopolar electrocoagulation/flotation (ECF) process

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Nitrate levels are limited due to health concerns in potable water. Nitrate is a common contaminant in water supplies, and especially prevalent in surface water supplies and shallow wells. Nitrate is a stable and highly soluble ion with low potential for precipitation or adsorption. These properties make it difficult to remove using conventional water treatment methods. A laboratory batch electrocoagulation/flotation (ECF) reactor was designed to investigate the effects of different parameters such as electrolysis time, electrolyte pH, initial nitrate concentration, and current rate on the nitrate removal efficiency. The optimum nitrate removal was observed at a pH range of between 9 and 11. It appeared that the nitrate removal rate was 93% when the initial nitrate concentration and electrolysis time respectively were 100 mg $L^{-1}$-$NO_3^-$ and 40 min. The results showed a linear relationship between the electrolysis time for total nitrate removal and the initial nitrate concentration. It is concluded that the electrocoagulation technology for denitrification can be an effective preliminary process when the ammonia byproduct must be effectively removed by the treatment facilities.



## 1. Introduction

The problem of nitrate ($NO_3^-$) is linked to the nitrogen cycle in groundwater. Excessive application of agricultural fertilizers has been known to cause penetration of large quantities of nitrates into underground and surface waters (Paidar et al., 1999). Nitrate is a water-soluble molecule made up of nitrogen and oxygen. It is produced when nitrogen from ammonia or other sources combines with oxygenated water. Other forms of nitrogen include nitrite ($NO_2^-$) and ammonia ($NH_3$) (Kapoor and Viraraghavan, 1997). Using of groundwater water supply is less expensive than those obtained from lakes, and rivers (Bouchard et al., 1992). In water sources, nitrate has no taste or smell, so it can be identified by a chemical test. The maximum acceptable concentration of nitrate in drinking water is 50 mg $L^{-1}$ as nitrate (NHMRC and ARMCANZ, 1996). High nitrate contamination in drinking water can cause methemoglobinemia, usually called "blue-baby syndrome", which is especially unfavorable to babies less than six months old (WHO, 2004).

Nitrates are serious environmental pollutants, as nitrate pollution of drinking water is generally a synthetic problem. Ordinary sources of nitrate pollution include discharge of chemical fertilizers, animal wastes, septic tanks, and municipal sewage treatment systems. Fertilizer is the largest supplier to nitrate pollution (Casland et al., 1998). Recent studies explained that an increase of nitrate concentration in the groundwater has been detected in some countries. In 1990, A US Environmental Protection Agency report on nitrate level in groundwater in U.S. showed that about 1.7 million people (including 270,000 infants) or 8% of population are exposed to nitrate concentrations above the regulatory limits of 10 mg $L^{-1}$ as N for drinking water (LLNL Nitrate Working Group, 2002). Nolan et al. (2002) reported that 9% of domestic wells sampled by the U.S. Geological Survey's National Water Quality Assessment (NAWQA) had nitrate concentrations over the acceptable level of 10 mg $L^{-1}$ as N. In British Columbia, the nitrate concentrations above the drinking water guideline were observed in some rural wells, particularly in intensive agricultural areas or locations near septic tanks. The results of groundwater samples obtained between 1977 and 1993 showed that from 12,000 samples analyzed for nitrate-nitrogen concentration, 186 samples (1.5%) had nitrate-nitrogen levels above the Canadian drinking water guideline of 10 mg $L^{-1}$ (GBC, 2002).

There are different technologies to remove nitrates from drinking water such as: ion exchange (Bae et al., 2002), reverse osmosis (Bilidt, 1985; Cevaal et al., 1995), electrodialysis (Elmidaoui et al., 2001; Kneifel et al., 1988; Wisniewski et al., 2001), catalytic denitrification (Ludtke et al., 1998; Reddy and Lin, 2000), biological denitrification (Dahab and Kalagiri, 1996), and electrochemical denitrification (Paidar et al., 1999; Sakakibara and Kuroda, 1993). Biological denitrification is the reduction of nitrate or nitrite to

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